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Media and representations in product design education

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MEDIA AND REPRESENTATIONS IN PRODUCT DESIGN EDUCATION

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ABSTRACT
The creation of product form, involves embodying a potential function and intended use while defining geometrical, ordering features. This paper aims to elaborate roles of different media and representations in design activities intended to externalise form ideas (e.g. sketching, building physical models, digital modelling, etc). To understand and explain the role of media in design activities, design diaries were analysed. These were documented as part of a master course in Advanced Form Design in spring terms 2011-2013. For course completion, the students were expected to work in groups on a project seeking creative form ideas and solutions for a dinnerware product with a high level of novelty, aesthetic detail, and functionality. Design diaries were used as an educational method for initiating and documenting self-reflections on a weekly basis. The paper discusses how different media may support design, but in some cases also constrain creativity and ability to work with three-dimensional form. Understanding and explaining this may help students and practitioners engage with, reflect on, and value the roles of media for externalising ideas.

Keywords: externalisation activities, media and design representations, design process

1 INTRODUCTION

The ability to make design representations is a central skill in design process. Designers engage in various activities, dealing with different media to externalise and represent their form ideas in e.g. sketches, physical and digital models. Design representations and the media used for creating them have different roles and support the designers' activities in various ways, e.g. sketching is considered the "heart" of the design process [1], "amplifying the mind's eye" [2], and supporting innovative design thinking [3]. Digital modeling, on the other hand, is regarded a threat in design, especially if the designers abandon their sketching practices [4], but has nonetheless become prevalent in product design education.

Design activities have a dialectic and reflective nature where designers respond to the changes they make in the environment [5]. This dialogue exists at different hierarchies: on the one hand, in the oscillation between the problem and solution space in the design process [see e.g. 6], on the other, between sketch moves. Schön and Wiggins [7] explain the conversational structure of sketching as a "seeing-moving-seeing" process that helps designers understand spatial relations. Goldschmidt [8] divides the sketching activity into moves and arguments relating to figural and conceptual properties of ideas (based on the inspection of sketches). According to Goldschmidt [9], creativity in the architectural design process is as a result of the interplay between these two types of reasoning. What these studies have in common is that sketching is seen as a preparation for further designing, built on and guided by prior moves. However, these studies focus on sketching activities, while research regarding the dialectic structure of other design activities (e.g. physical or digital modeling) is relatively sparse. In an earlier literature review [10], different ways in which sketching, physical and digital modeling facilitate design processes were identified. These involve physical (e.g. generation of alternatives), sensory (e.g. visual and tactile aid) and cognitive aspects (e.g. memory and retrieval aid).

The aim of this paper is to investigate how the identified roles from the literature review are manifested in empirical material, allowing for a comparison and further elaboration. Comparing and contrasting the roles that different activities fulfill, supports understanding of the dialectic nature of design and may highlight directions for product design education.

2 DIARY STUDY

To understand and explain the role of media in design activities, design diaries were used. These were documented as part of a course in Advanced Form Design (7,5 ECTS - master level) in spring terms 2011-2013 with a total of 38 participants. The students were to look for approaches that would lead to a creative and experimental yet structured generation of formal product solutions. Through an explorative process from abstract form generation to a concrete product design development, the students work in groups on a project seeking creative form ideas and solutions for a dinnerware product with a high level of novelty, aesthetic detail, and functionality.

2.1 data collection and analysis

Design diaries were used as an educational method for initiating and documenting self-reflections on a weekly basis [on educational benefits of using diaries see 11]. The students were to reflect on their process and the underlying motivations behind their activities using a structured template (see structured diary format see ibid.). Design diaries from the study year 2011-2012 (a total of 11 participants) were included in content analysis. A top-down analysis was carried out using concepts identified from the earlier literature review. According to Dey [13], 'creating categories is both a conceptual and empirical challenge; categories must be grounded conceptually and empirically'. The collected diaries were printed and used for coding and memoing. This involved (i) identifying and grouping diary entries into sketching, physical and digital modeling activities, (ii) categorizing diary entries based on the literature review, (iii) identifying sub-categories to complement the literature review, and (iv) tabulating the findings for comparison.

3 RESULTS AND DISCUSSIONS

Figure 1 presents an overview of the roles identified from the literature review and their manifestations in the design diaries. Important issues regarding the identified roles and their implications for design process are discussed here.

3.1 Conversations within and across media

The analysis of different activities in design diaries indicates a recursive relationship between materialising and inspecting ideas, where physical roles favour materialising ideas, and sensory roles favour inspection of ideas. The interplay between materialising and inspecting (or Schön's seeing-moving loops in sketching) gives rise to cognitive roles (e.g. the emergence of new ideas), and thereby stimulates creativity. This applies not only for sketching, but also to physical and digital modeling. Furthermore, seeing-moving loops can be seen at higher conceptual level between different activities i.e. moves between sketching and physical modeling:

[EM, W4, Sketching after a physical modeling session:] "Some of the workshop outcome was not very self-evident, but more a way of stimulating new ideas and thoughts, therefore it had to be interpreted right away."

Translating ideas from one type of representation to another was often reported in design diaries (e.g. sketching from mood-boards, collages, physical and digital models, see figure 2).

Reframing prior ideas using a new medium facilitates interpretation and leads to finding geometric relations that would otherwise be hidden in one representation. This is shown in studies regarding sketches, where restructuring and translating of visual components facilitated discovery of new information and patterns [see e.g. 14]. Moreover, materialising ideas in different forms facilitates discovery and correction of the poor assumptions that are not revealed in previous representations, and thereby, learning from previous mistakes. Designers learn from experimenting and communicating with models since they respond to physical behavior [e.g. 15, 16]. This was especially clear when sketches and digital models were turned into physical models:

[Av, w4:] "I found more inspiration and interesting shapes when working with the clay… [W5:] When studying our clay models and looking back on the board and analysis of our initial form category I realized that the transition lines between surfaces that are curved and multi force; curved in one direction and appears as twisted, are suitable for us… We found one particularly interesting form that triggered more new ideas, which we then decided to develop further."

[AV, W7:] "We have built physical models in Styrofoam. Our measurements turned out to be slightly to big, why we decided to scale down the dinner set. It felt very valuable to make the physical models."

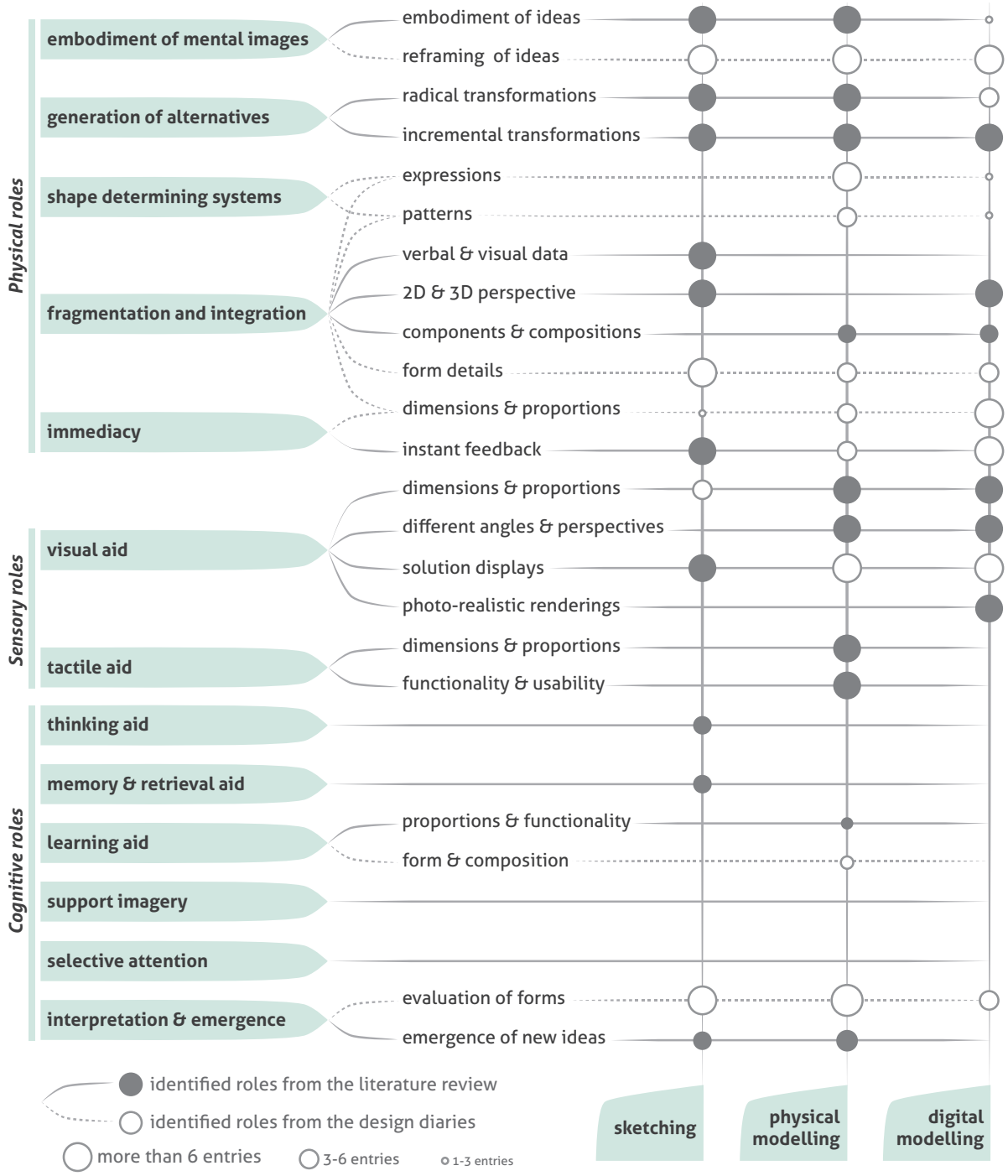

Figure 1. Roles of externalisation activities in design diaries.

3.2 Immediacy and fluency

Diary entries regarding the activities that involve immediate feedback and are perceived suitable for 'fast form generation' included sketching, digital and physical models. Some researchers however have discussed that immediacy is exclusive to sketching which helps reducing complexity and relieving the memory load through appearance of an immediate trace of ideas provided that the designer has fluency in sketching [e.g. 17]. According to Robertson and Radcliffe [18], technical problems encountered in a CAD environment prevent the designers from instantly materialising their ideas, and thereby distracts them from creative problem solving. The remarks on immediacy of digital media in design diaries illustrate students' fluency and skill in manipulation of digital media facilitating idea generation without necessarily being bounded to and distracted by technical problems. This may, moreover, lead to creating a large number of alternative solutions with little delay imagining ideas to materializing them and thereby stimulating creativity.

[AV, W2:] "I found sketching to be a suitable first method of form development because that is what I found easiest and the fastest way to explore thoughts and try forms. To think with the pen."
[EK, W5, on clay modelling:] "We wanted to get a physical feeling of the shapes that we work with and also needed this to try some more complicated ideas in a fast way."

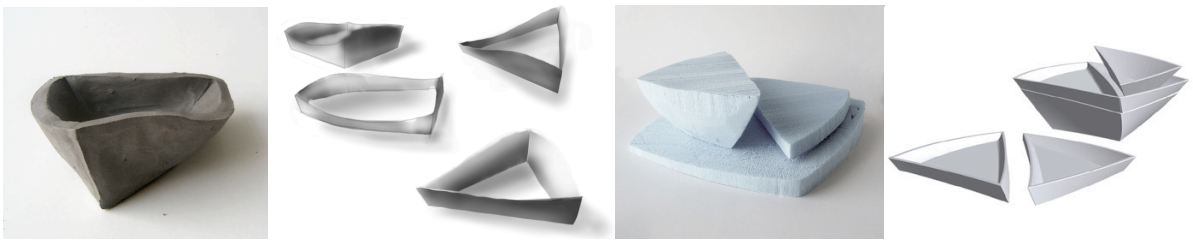

Figure 2. Example of translation of solutions using different media.

3.3 Inspecting solutions

Inspecting and studying proportions and spatial relations was frequently mentioned in the design diaries, especially through using matrices and tables that were created as a structured display of prior ideas. One of the benefits of sketching, according to Goldschmidt [8] is the trace that is left which facilitates the designers' cognitive process. This also applies to digital and physical models, as the students made use of them parallel to their sketches in structured matrices (e.g. figure 3). Capturing and freezing traces of progress in physical models may however require additional effort.
[AV, W2:] "We needed to organize and refine our selection of forms, so we cut out all the images and grouped them as we thought they belonged together."

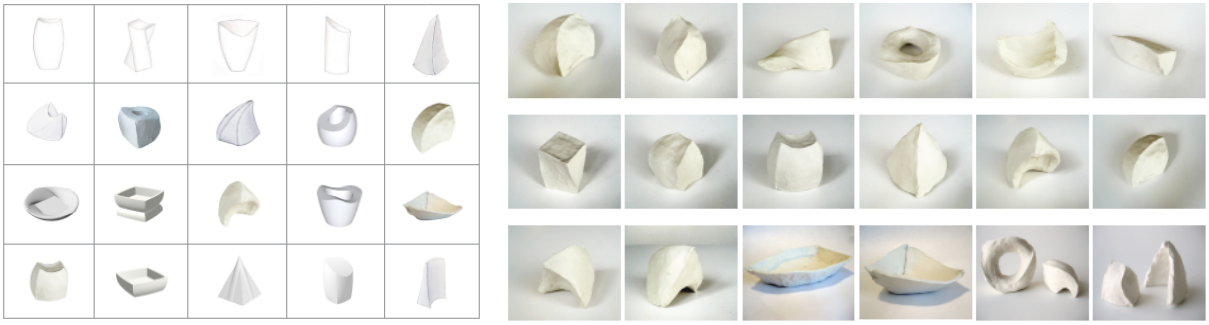

Figure 3. Making solution displays for inspection of precedent ideas.

3.4 Media and representations as impediment to creative progress

Fixedness

In several cases, students seem to get caught up in a potential solution in an early phase of the process. Functional fixedness is "the tendency to be rigid in how one thinks about an objects' function" [19]. Jansson and Smith [20] found that the design fixation among engineering design students is due to the precedent solutions that designers look at, preventing them from finding innovative alternatives. Fixation on precedents can be seen in two ways: already existing products, and designers' own representations of potential solutions. The latter has been discussed by Robertson and Radcliffe [18], regarding CAD models causing resistance to major changes. In the present study, this was noted in physical modeling where a potential solution for one piece not only caused resistance against making major changes for that piece, but also governed the remaining parts of the design (e.g. figure 4):

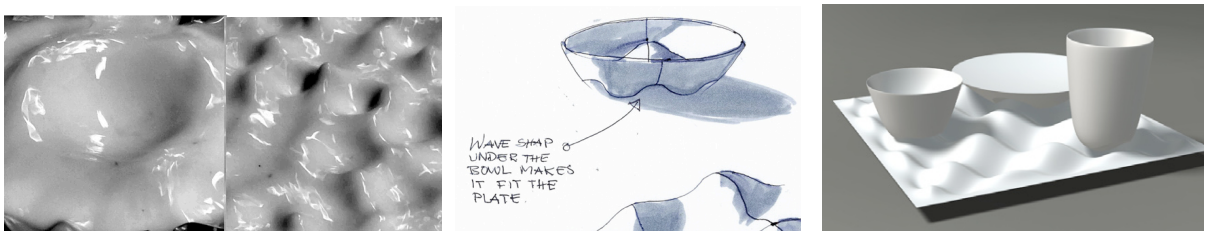

Figure 4. Example of fixation from a modeling experiment with water, sound and vibration.

"[JN, W2:] We decided to project light through a liquid that was under vibration by a sound source... [W6:] We wanted to imitate the shape that was generated from the experiments… We had a big difficulty on the pattern for the plate. We earlier decided to go for a linear pattern but we then realized that it is impossible to place the items on the plate. We spent a lot of time on this pattern without going anywhere… It was difficult to create the complicated and very organic shaped that we had in our mind and that was generated by our experiences by using CAD modeling."

Designers' repertoires of potential solutions and form ideas may also play an important role in functional fixedness. Purcell and Gero [21] found that design fixations occur due to lack of domain specific knowledge and falling back on everyday experiences. A limited repertoire may also contribute to premature fixations, where the designer conforms to the solutions that are easily achievable different media.

Shape determining systems

Different activities give rise to and encourage certain form solutions, which can be seen both as contributing to a larger pool of choices, and more creative freedom but also as constraining what one can do if one only relies on a specific medium. Pye [22] discusses that drawing gives shape to and determines forms that are made up geometrically, since it is easier to make them using drawing instruments and communicate them with others in terms of basic elements. Robertson and Radcliffe [18] also point out a problem with CAD systems where the designers' ideas stay limited to not only what is possible by the medium but to what is easiest and most available.

This was noticeable for all of the activities in design diaries. For example, the difficulty to use patterns while sketching discouraged the students from experimenting with patterns in their form solutions. Smooth and curved forms were encouraged, while creating solutions with thin walls were discouraged when making clay models. Making sharp transitions, working with concave and convex surfaces in oval shapes were found to be easier in the CAD systems used by the students. Making organic and complex shapes was on the other hand found difficult according to the diary entries.

By making a form easier or more difficult to achieve, media have a role in determining and governing designers' solutions. This can lead to premature fixedness and resistance to major changes, especially if designers have limited form repertoire and lack of experience with the specific product type.

Mental gaps

One of the main problems mentioned in the diaries, is an incongruence of students' mental images and their design representations, e.g. how a physical model looked different from the sketched ideas, how the digital model is incongruent with its prior representations, or how sketching lacks three dimensional feeling. While these may be shortcomings of the medium, they can also be due to ones' limited spatial thinking abilities or skills in manipulating the media. Research regarding designers' spatial thinking ability is however limited.

3.4 Reflections on the use of diaries

Investigating the interplay between different design activities requires longitudinal studies that span over a whole design process. Using diaries as a data collection method allow for recording these activities along with designers' self-reflections. Diary methods, however, involve a delay between the occurrence of the event and data collection, it does not capture the on-going cognitive aspects of design activities (e.g. supporting imagery and selective attention were not exhibited in design diaries, see figure 1). To capture the cognitive roles that different activities may involve, concurrent data collection methods e.g. think a loud may be more appropriate.

4 CONCLUSION

The roles identified for different externalization activities may in design education serve as a platform for mediating discussions, and reflections on the use of media and representations. However, they concern students' activities when designing dinnerware objects. Further studies especially with other products types may complement the findings.

Design progress can be seen, as interplay of moving-seeing not only within one way of externalising, but also across different media. In the design diaries the students engaged in a dialectic process when translating their ideas from one medium to another. This requires conversing both with precedents and the evolving translations, providing opportunities for reinterpretation of ideas. Moreover, learning may

happen when translating ideas from one medium to another. Creating educational situations to encourage the students iterate more often using different media, may result in reaching more well-reasoned solutions.
The extent to which students can learn from this process depends on their skill in manipulating media. The results from diary analysis show that eloquence in using digital media leads to perceived immediacy, creation of more alternatives, and overcoming limitations of shape-determining systems. This accentuates a need to help design students become more skilled in using different media, thereby enabling a fluent exploration of novel solutions.

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